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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN - 2 1998

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: FY 1998 Appropriations Reporting Requirement on Perchlorate

FROM: Stephen A. Lingle *Stephen A. Lingle*
Acting Deputy Assistant Administrator for Management (8101R)

TO: Dana D. Minerva
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Office of Solid Waste and Emergency Response (5101)

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Acting Deputy Regional Administrator
Region IX

William W. Rice
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PURPOSE

The purpose of this memorandum is to request that the Office of Water (OW), the Office of Solid Waste and Emergency Response (OSWER), and Region VII and IX review and comment on the attached draft Report to Congress, "Perchlorate: Assessment of the State of the Science."

BACKGROUND

In the Conference Report (Committee Report 105-115, October 6, 1997, see Attachment B), to accompany the 1998 Appropriation Bill, Congress directed the



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U.S. Environmental Protection Agency to work with the U.S. Department of Defense (DoD), National Institute of Environmental Health and Sciences (NIEHS), and other appropriate federal and state agencies to:

- (1) Assess the state of the science on the health effects of perchlorates on humans and the environment and the extent of perchlorate contamination of our nation's drinking water supplies, and
- (2) Make recommendations to the House and Senate Committees on Appropriations within six months of enactment of the 1998 Appropriation Bill on how this emerging program might be addressed.

The Office of Research and Development's (ORD) National Center for Environmental Assessment (NCEA) developed the attached draft Report to Congress in conjunction with representatives from OW (Mike Osinski), OSWER (Peter Gravatt), and Region IX (Wayne Praskins and Kevin Mayer), as part of an Interagency workgroup, the Interagency Perchlorate Steering Committee. We are also providing a copy of this draft to Region VII, as ORD's lead Region.

ORD requests your review and comment on the report, so that it can be finalized and provided to the Office of Management and Budget for their review. We would appreciate receiving your comments by Wednesday, June 10, 1998, so that we may incorporate them and provide the Agency with a final version when possible. Please provide your comments to Joe Corbett of NCEA at your earliest convenience. If you have any questions, please contact Joe at 202-564-3352.

Attachments

cc: Larry Reiter, ORD
Bill Farland, ORD - {cx}
Debbie Dietrich, ORD
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PERCHLORATE: ASSESSMENT OF THE STATE OF THE SCIENCE EPA OFFICE OF RESEARCH AND DEVELOPMENT MAY, 1998

In the Conference Report (Committee Report 105-115, October 6, 1997) to accompany the 1998 Appropriation Bill, Congress directed the U.S. Environmental Protection Agency to work with the U.S. Department of Defense (DoD), National Institute of Environmental Health and Sciences (NIEHS), and other appropriate federal and state agencies to:

- (1) Assess the state of the science on the health effects of perchlorates on humans and the environment and the extent of perchlorate contamination of our nation's drinking water supplies, and
- (2) Make recommendations to the House and Senate Committees on Appropriations within six months of enactment of the 1998 Appropriation Bill on how this emerging program might be addressed.

WHAT IS PERCHLORATE?

Perchlorate anion (ClO_4^-) originates as a contaminant in ground and surface waters from the solid salts of ammonium, potassium, or sodium perchlorate.

Ammonium perchlorate is manufactured for use as an oxidizer component in solid propellant for rockets, missiles, and fireworks. Because of its shelf life, it must be periodically washed out of the country's missile and rocket inventory and replaced with a fresh supply. Thus, large volumes of the compound have been disposed of in California and likely other sites since the 1950's. Ammonium perchlorate is also used in certain munitions, fireworks, the manufacture of matches, and in analytical chemistry. *States*

Potassium perchlorate had, until recently, been used therapeutically to treat hyperthyroidism resulting from an autoimmune condition known as Graves' disease. Potassium perchlorate is still used diagnostically to test thyroid hormone (TSH, T3 and T4) production in some clinical settings. The basis for the effect on thyroid hormone function is the competitive inhibition of iodide anion uptake by perchlorate which results in reduced thyroid hormone production. Thyroid hormone deficiencies can affect normal metabolism, growth and development. The limited database on the toxicology of perchlorate confirms its potential to disrupt thyroid hormone production in mammalian test species, but no robust data exist to evaluate other potential target tissues or effects. There are no data to evaluate the effects of perchlorate in potentially susceptible population such as developing fetuses or its effects on ecological systems.

Perchlorate salts are quite soluble in water. The resultant anion (ClO_4^-) is exceedingly mobile in aqueous systems and can persist for many decades under typical groundwater and surface water conditions, due to kinetic barriers to its reactivity with other available constituents. Recent (April 1997) advances in the analytical detection capability for low concentrations of perchlorate [from 400 parts per billion (ppb) to 4 ppb] have led to the discovery of the chemical at various manufacturing sites as well as in well-water and the drinking water supplies of communities in California, Nevada, and Utah. Perchlorate has been found at ~~the~~ Superfund National Priorities List (NPL) sites in California (Aerojet and Mather Air Force Base, San Gabriel Valley, National Aeronautics and Space Administration (NASA)-Jet Propulsion Laboratory (JPL), Edwards Air Force Base and unconfirmed samples at the San Fernando Valley site), at ~~the~~ other California non-NPL sites, two sites in Henderson, Nevada area and at ~~one site in Utah~~. Water suppliers in both northern and southern California, and the Las Vegas Water Authority have found perchlorate in their systems generally at levels less than 18 ppb but ranging as high as 280 ppb, with several in the 100-200 ppb range. Perchlorate has been detected at low levels (5 to 9 ppb) in the Colorado River, which potentially affects the water supply of over 1 million in Nevada, 1 million in Arizona and over 10 million in California as well as Native Americans along the river.

SCIENTIFIC UNCERTAINTIES

Perchlorate is of concern because of the existing uncertainties in (1) the toxicological database documenting its health effects at low levels in drinking water, (2) the actual extent of the occurrence of perchlorate in ground and surface waters which is compounded by some uncertainty in the validation of the analytical detection method, (3) the efficacy of different treatment technologies for various water uses such as drinking water or agricultural application, and (4) the extent and nature of ecological impact or transport and transportation phenomena in various environmental media.

Perchlorate does not have a National Primary Drinking Water Regulation (NPDWR) or Health Advisory (HA) established. In accordance with the 1996 amendments to the Safe Drinking Water Act (SDWA), the Environmental Protection Agency (EPA) is required to develop a list of contaminants that are potential candidates for future drinking water research, guidance development, and future regulation, if necessary. Based on response to public comment received on its draft list published on October 6, 1997 (62 FR 52193), perchlorate has been included on the Contaminant Candidate List (CCL). At this time, the CCL notes that additional data on health effects, occurrence, analytical methods and treatment technologies are needed for perchlorate before decisions can be made to (1) regulate with a NPDWR, (2) develop guidance and/or a HA, or (3) do nothing. This list will also serve as a source to identify unregulated contaminants for required monitoring by the States. There are bills pending in the California state legislature (SB 1033) to mandate that the California Department of Health Services (CalDHS) adopt a primary drinking water standard by July, 1999. California has also initiated legislation to appropriate funding to the University of California to conduct a study and

assessment of the occurrence, treatment, and health effects associated with groundwater contamination from perchlorate (AB 2392 February 20, 1998).

The EPA Superfund Technical Support Center issued a provisional reference dose (RfD) in 1992 and a revised provisional RfD in 1995, resulting in a recommended range of 4 - 18 ppb as a guide for ground water cleanup levels at Superfund sites. The CalDHS adopted the provisional action level of 18 ppb, and EPA's Region III has placed this provisional value on its Risk-Based Concentration Tables.

Based on detection of perchlorate in drinking water sources along the Crafton-Redlands plume in the East Valley Water District (EVWD), and concern for the uncertainties and issues listed above, the FY98 appropriations provided a Congressional add-on of \$2M for research on perchlorate, with an emphasis on treatment technologies. In anticipation of this funding, the EVWD, in cooperation with four other water suppliers (Main San Gabriel Basin Watermaster, Metropolitan Water District of Southern California, San Bernardino Valley Municipal Water District, and the Southern Nevada Water Authority) sponsored a research planning workshop which they requested the American Water Works Association Research Foundation (AWWARF) to organize and manage. The AWWARF staff agreed and convened an expert workgroup that included the CalDHS, EPA Region IX, university professors and researchers, Aerojet and the United States Air Force (USAF), consultants and other research experts as well as technical representatives of the sponsoring water utilities. Using a modification of the planning process for other AWWARF research issue groups, the AWWARF conducted the workshop in Ontario, California, on September 30 to October 2, 1997 to develop and prioritize project descriptions. The overall research plan covered 4 years, 1998 through 2001. The Request For Proposal (RFP) for eight of those projects went public during the week of Monday, March 9, 1998. These eight projects include seven that are to be funded by the Congressional FY98 Crafton-Redlands allocation of \$2M. The eighth project is an occurrence survey funded strictly by AWWARF monies. Once the proposals submitted in response to these RFPs are evaluated, contract awards for the seven RFPs to be funded from federal resources are contingent upon release of the designated funding by EPA and the availability of subsequent funding for the duration of the projects.

INTERAGENCY PERCHLORATE STEERING COMMITTEE (IPSC):

An Interagency Perchlorate Steering Committee (IPSC) was formed in January 1998 to bring together government representatives from the EPA, DoD, Agency for Toxic Substances and Disease Registry (ATSDR), National Institute for Environmental Health Sciences (NIEHS), and affected state, tribal, and local governments. Its charter is to facilitate and coordinate accurate accounts of related technical issues (occurrence, health effects, treatability and waste stream handling, analytical detection, ecological impacts, regulatory updates) and to create information transfer links for interagency and intergovernmental activities regarding these areas of concern.

There has been growing interest by various parties to benefit from public briefings and meetings held by the IPSC. An especially interested sector is the impacted water authorities who are keen to learn the most accurate information to communicate to their customers. Monthly teleconferences are held to update participants on events and breaking news regarding controversial or technological issues. A public meeting is currently being planned for mid-May in Henderson, Nevada, to distribute the most current scientific information on the key issues and to hear stakeholder and public concerns. Participation in the IPSC has also been solicited from other governmental members, including the Department of the Interior.

Stakeholder forum was held

Information on the state-of-the science has been compiled by subcommittees of the IPSC devoted to each of these areas and a summary discussion for each is presented below. This report has been developed by EPA's Office of Research and Development (ORD) in conjunction with the IPSC regarding work required to address the existing areas of concern and uncertainties regarding characterization of the risk of perchlorate contamination in ground and surface waters. This report recommends areas of research for future consideration to address the emerging perchlorate risk characterization issues.

Occurrence Surveys: There has not been a systematic or widespread survey of perchlorate occurrence. Only a small number of water supplies have been monitored at the new level of detection sensitivity, and these have primarily been in the Western States with a few sample results now available in the South. EPA and the State authorities are working together to intercept contaminated groundwater where it has been identified. Reporting of occurrence data is confounded by discrepancies in the type of analytical method used and its detection level of sensitivity. Occurrence information is also likely to be variable due to seasonal water turnover and mixing due to temperature changes, as has been demonstrated in Lake Mead.

An additional National Assessment of Perchlorate Contamination Project was approved by the Board of Trustees of AWWARF for their sponsorship and funding. The RFP for this project went public the week of Monday, March 9, 1998, with proposals due May 4th. The project is proposed as a \$150K AWWARF contract with a required 25% matching in-kind support of the total budget provided by the successful bidder, resulting in an overall project budget of \$200K. It is expected that the contract for this work will be completed in the summer of 1998, with the project to initiate shortly thereafter.

The majority of confirmed sites where perchlorate has been released to the environment in EPA Region IX are associated with operations manufacturing or testing solid rocket fuels for the military or NASA (e.g., Aerojet, NASA-JPL, Lockheed Propellants, Alliant/Hercules, Rocketdyne). The other two known release sites are perchlorate manufacturing facilities in Henderson, Nevada, including the former Pacific Engineering and Production Company (PEPCON) operation. Levels in Utah range from 4 to 200 ppb in ground water wells on the property of rocket motor manufacturer Alliant Techsystems. Wells near the PEPCON explosion site ranged from 51.4 to 630 ppm (51,400 - 630,000 ppb) and those near the manufacturer Kerr-McGee Corporation showed levels as high as 3,700 ppm (3,700,000 ppb). Testing by the

explains

Los Angeles Metropolitan Water District found 8 ppb at its intake and in Lake Mead at Hoover Dam. The Southern Nevada Water Authority found levels as high as 14 ppb in its public water supply. The Nevada Division of Environmental Protection reports a approximately 1 ppm (1,000 ppb) entering Lake Mead from the Las Vegas Wash. Some samples of Lake Mead surface water were reported as high as 165 ppm (165,000 ppb) near the Las Vegas Wash with most samples in the 10 to 50 ppb range.

EPA Region VI has identified facilities having manufactured or handled perchlorates in some capacity and forwarded this list as well as laboratory analysis information to the Texas Natural Resource Conservation Commission (TNRCC), the Arkansas Department of Pollution Control and Ecology, and the Oklahoma Department of Environmental Quality, as well as to the CERCLA project manager of Longhorn Army Ammunition Plant, with the recommendation that the ground and surface waters near these facilities be tested for perchlorate. Results at one facility (Atlantic Research in Arkansas) were nondetectable perchlorate levels, but the method used had a limit of 1 ppm (1,000 ppb). Levels at the Longhorn Army Ammunition Plant reported storm drain discharge to a creek at 200-400 ppb and the creek discharge into Caddo Lake at 11 ppb; solid perchlorate residual was visible on the soil surface.

Systematic and widespread survey of perchlorate contamination is warranted. EPA anticipates the need for additional field sampling and analysis at sites where perchlorate releases may be contaminating ground or surface water. New information on potential sites across the country is forthcoming from DoD and NASA searches; information requests from perchlorate manufacturers; and from the proposed AWWARF occurrence study. EPA has started to notify State and local governments and tribes when the Agency receives evidence of perchlorate manufacture and use in their jurisdictions. However, due to limited resources and analytical capability, these governmental entities may not be able to investigate further. It is recommended that the EPA regional offices identify facilities having manufactured or handled perchlorate and oversee conducting sampling of ground and surface water near these facilities. Results should be compiled in a report for distribution by the IPSC. A nationwide effort to characterize possible perchlorate contamination in ground and surface water sources of drinking water in areas of high risk is recommended. Such an occurrence characterization would build upon the vulnerability assessment (survey screen) funded in FY98 by AWWARF, and delineate the nature and extent of contamination at critical sites and evaluate the impact on drinking water supplies as well as other potential sources (e.g., sample water systems, surface and ground water sources). The AWWARF perchlorate issue group had proposed a project for such a survey, but the EVWD has indicated that they intend to focus on treatment issues instead.

Health Effects/Toxicology: The toxicology data available to evaluate the potential health effects of perchlorate are extremely limited. The provisional RfD values (1992 and 1995) issued from the EPA Superfund Technical Support Center were based on an acute study in which single doses of potassium perchlorate caused the release of iodide from the thyroids of patients with Graves' Disease. The uncertainty factors applied to these data ranged from 300 to 1000. Standard assumptions for ingestion rate and body weight were then applied to the RfD to calculate the reported range in the ground water cleanup guidance levels of 4 -18 ppb.

The outcome of an external peer review convened in March 1997 of an analogous RfD derivation by an independent organization, Toxicology Excellence for Risk Assessment, was the determination that the health effects and toxicity data were insufficient for a credible quantitative risk analysis. The external peer review panel concluded that the data were not sufficient to rule out effects of perchlorate on other organs, so that it could not be determined unequivocally that the effects on the thyroid were the critical effect. In particular, the reviewers were concerned that developmental toxicity, notably neurological development due to hypothyroidism during pregnancy, could be a critical effect of perchlorate that has not been adequately examined in studies to date. In response to that review, a subsequent external peer review of experts was convened in May 1997 to recommend and prioritize a set of studies to address the key data gaps and reduce uncertainties in various extrapolations. Eight studies were recommended and these were then initiated under various contracts. The recommended studies included: (1) a 90-day subchronic study in order to identify other target tissues and fulfill the minimum database requirement for derivation of an RfD; (2) a neurobehavioral developmental study (evaluates nervous system of fetal, newborn and young animals) to identify a potentially critical effect and subpopulation; (3) a Segment II developmental study (evaluates birth defects) to identify a potentially critical effect and subpopulation; (4) a two-generation reproductive study (evaluates reproductive performance in adults and for toxicity in young animals) to identify a potentially critical effect; (5) studies to understand the pharmacokinetics (how perchlorate is absorbed, distributed, metabolized and excreted) of perchlorate in test animals and humans; (6) cross-species studies of the effects of perchlorate on the iodide uptake mechanism to aid in quantitative extrapolation; (7) genotoxicity assays to evaluate the potential for carcinogenicity by evaluating mutations and toxic effects on DNA; and (8) immunotoxicity studies to identify a potentially critical effect. Funding for the studies was procured and obligated through a variety of sources, principally the USAF and the Perchlorate Study Group (PSG).¹ The protocols for the studies were reviewed by external peer reviewers from the EPA, California EPA, academia, industry, private institutes and Health Canada. EPA's ORD will evaluate the results of these studies as they become available and integrate the new health effects information into a new health assessment in order to revise the provisional RfD derivation by September 1998. EPA's Office of Solid Waste and Emergency Response (OSWER) has the lead on establishing an external peer review of this RfD health assessment in October 1998. This revised and peer reviewed RfD based on a key set of new studies will serve to more accurately characterize the potential health risk associated with perchlorate contamination.

At this time it appears that an adequate set of studies are underway to comprehensively evaluate the potential health effects of perchlorate in laboratory animal studies. The Department of Defense and the PSG have collectively funded the above eight studies costing \$2.2 M (see Appendix A). Additional work may be required to mathematically model the dosimetry (pharmacokinetics) and toxic effects in order to increase the accuracy of a health risk determination, but this will need to be evaluated as the new data become available. An epidemiological study has been proposed to look at infant thyroid hormone data from mothers who were exposed in their drinking water supplies. The analysis would rely on the dose

¹The PSG is a consortium of defense contractors and manufacturers including: Alliant Techsystems, American Pacific/Western Electrochemical Company, Atlantic Research Corporation, Lockheed Martin, Thiokol Propulsion Group, and United Technologies Chemical Systems.

reconstruction data to the level of either a city or census block and will assume either that all women who lived in that area were exposed to that level of perchlorate or impose standard assumptions from other such studies (e.g., 20% of women drink bottled water). The dose reconstruction of what was in the water would have to be constructed on occurrence data once the hydrology in the aquifers and transport and transformation processes can be worked out. The study was proposed by the CalDHS to ATSDR. ATSDR is currently providing the equivalent of one year's salary in staff support for this project in FY 98. However, CalDHS has requested increased support above current levels of staff support.

It appears that an adequate set of studies are underway to comprehensively evaluate the potential health effects of perchlorate in laboratory animal studies. Additional work is warranted to describe quantitatively the dosimetry (pharmacokinetics) and toxic effects with a mathematical model in order to increase the accuracy of a health risk determination. Additionally, research will help to predict quantitatively the effect of perchlorate on iodide uptake (i.e., calculate the inhibition kinetics for the symporter in the thyroid), and subsequent effects on thyroid hormone (TSH, T3 and T4) production, transportation, and metabolism in adult male and female rats and in the developing rat and mother. Development of the dosimetry model would be best accomplished if performed at the Air Force Research Laboratory/Operational Toxicology Branch (AFRL/HEST), due to its previous experience with dosimetry models for developmental toxicity, and in conjunction with intramural support of scientists involved with the health assessment in EPA.

Analytical Detection Methods: Because analytical methods are critical to determining occurrence levels in drinking water supplies and other sources, the urgent need for analytical development work is evident. Historical data based on gravimetry, spectrophotometry, and atomic absorption spectrometry are unreliable because those methods are non-specific for perchlorate. Ion chromatography (IC) is the state-of-the-art technology for analysis. There are several existing IC methods, including the recent analytical method developed by the CalDHS, and Dionex, and one developed by the Air Force Research Laboratory/Operational Toxicology Branch (AFRL/HEST). These methods depend upon retention time in a standard to identify any peak with the same or similar retention time as perchlorate in a water sample. It is not known nor has it been demonstrated that other constituents present in water may have similar retention times or interfere with perchlorate at these low detection levels. The robustness of existing ion chromatographic methods for the analysis of perchlorate in water with high total dissolved solids (TDS) has been questioned. The AFRL/HEST has a validation project underway (\$80K in FY98) to conduct a collaborative study across approximately 22 laboratories from all sectors to evaluate the robustness of the existing ion chromatographic methods (including the CalDHS IC method) to detect perchlorate in three types of matrices (low, mid, and high dissolved solids and a negative control) at four different perchlorate concentrations. The objective is to evaluate the variability, reproducibility, accuracy and precision of the IC methods across laboratories and to determine the concentration range of their efficacy in case a different method should prove more suitable for high concentrations. The report of the study is anticipated in July 1998.

There is an overlap with three proposed AWWARF projects, "Survey of the Performance of the CalDHS Analytical Protocol" (\$94K from FY98 EPA/Crafton-Redlands allocation), "Short-term

Perchlorate Laboratory Issues" (\$125K from FY98 EPA/Crafton-Redlands allocation), and the "Inter-Laboratory Study for the Performance Evaluation of the CalDHS Method. While the AFRL/HEST study focuses on TDS as the only water quality parameter of interest, AWWARF was anticipating information on specific interfering ions and a rigorous evaluation of the detection limits for perchlorate. Enhanced coordination of the analytical activities, notably between those of the USAF and AWWARF, has been encouraged by the IPSC and is being pursued.

Waste water methods for samples with high perchlorate concentration and high TDS are needed as well and research should be pursued in parallel. The IC detection method should also be supported by an acceptable alternative method, based on a different principle to verify concentrations of field samples. Two or three analytical methods most likely to achieve success should be pursued for detailed development. These might include, but are not limited to: capillary electrophoresis, liquid chromatography/mass spectrometry, bioassay methods, coulometric detectors, and selective ion-pair agent methods. Development of an alternative method was a project proposed for RFP solicitation by AWWARF.

The FY98 interlaboratory validation study underway by the AFRL/HEST and the FY98 proposed projects by the AWWARF will provide data to evaluate how much additional effort will be required to develop a robust method. Only one aspect of the original analytical method development projects proposed, that of determining the impact on the CalDHS IC method detection limit by potential interferences, remains to be evaluated. Alternative methods to support issues related to natural occurrence studies and health or ecological impact assessments may require development of specific methods for various environmental or biological matrices. Research and development of these alternative methods is recommended. It is also recommended to pursue waste water technology in parallel. Once available, the EPA's Office of Water (OW) should review the results of these analytical methods studies to evaluate their appropriateness for publication as a standardized EPA analytical detection method for perchlorate.

under in ground water (surface water) under typical environmental conditions

Treatment Technologies: Perchlorate anion is very unreactive towards most reducing agents when cold and dilute and has low reactivity as an oxidant due to kinetic barriers. These same properties make developing treatment technologies difficult, especially at low concentration levels. No one technology or process will likely provide an effective solution for every occurrence of perchlorate contamination in water supplies due to a large number of independent variables. These include, but are not limited to, perchlorate contamination levels, aquifer types, hydrogeology, and the scale and attributes (e.g., soil or water type) of the site to be remediated; the presence of co-contaminants; Federal, state and local regulatory constraints; public acceptance; inherent technology or process limitations and side effects; and capital and operating costs. Technology evaluation criteria may also be a function of the intended use of the treated water (e.g., drinking water versus agricultural application). Technologies and processes have been developed by industry and the Air Force Research Laboratory - Materials and Manufacturing Directorate (AFRL/MLQE) to recover perchlorate for reuse and to treat residual wastewater containing high concentrations (500-10,000 ppm) perchlorate from the manufacture and maintenance of rocket motors. It is important to note that, to date, the USAF has spent in excess of \$10 M for research and development for these technologies and processes to address high-concentration contamination. A new challenge exists in treating low-concentration (5 ppb to

500 ppm) perchlorate present in ground and surface water supplies. These contaminated water bodies are sources of municipal drinking water, and as such, are constrained by regulations with respect to treatment processes that may be applied.

Treatment technologies for addressing perchlorate-contaminated water may be grouped into three general categories: (1) biological and biochemical reactor treatment systems, (2) conventional chemical reactor treatment systems, and (3) separation and concentration technology. The further development of technology in each of these areas will be necessary and essential to provide technically sound, cost-effective treatment options for managing a wide range of perchlorate concentration and water supply situations. Each technology or process has either technical limitations or has not been demonstrated for treating low-concentration perchlorate-contaminated water and requires further development. Drinking water authorities may desire, or be compelled, to reduce the perchlorate level in affected supplies below a legislated value. As such, the need for treatment technology for very-low concentration levels exists regardless of the findings of the toxicology studies.

There is currently no treatment process that has been demonstrated effective for treating low-concentration (10 ppb to 500 ppm) perchlorate available for use on drinking water supplies or for treating contaminated groundwater. The limitations of existing technologies warrant research in technology development and demonstration of perchlorate treatment process systems. Based on the results of the toxicology studies being conducted, the technology development strategy will be adjusted, if necessary, to produce short-term treatment options unconstrained by capital and operating cost factors, followed by longer-term more cost-effective solutions. It will also be important to establish criteria and ratings for treatment technology effectiveness, e.g., the ratings available from the National Sanitation Equipment Foundation.

The following areas of research are recommended for future consideration:

- Biological and biochemical reactor treatment systems
- Conventional chemical reactor treatment systems
- Separation and concentration technology
- Development of home treatment devices

The Air Force Research Laboratory – Materials and Manufacturing Directorate (AFRL/MLQE) has extensive experience and expertise in developing and implementing chemical and biological process technology, and in developing and evaluating high-concentration perchlorate treatment technology. The IPSC believes that technology development activities be accomplished through teaming arrangements involving the following organizations: the AFRL/MLQE, AWWARF, EPA innovative technology, respective drinking water authorities in affected areas, and commercial developers and suppliers of drinking water treatment processes.

The Treatment Technology Subcommittee of the IPSC would be the appropriate entity to ~~should~~ (1) collect and disseminate information regarding treatment technology development activities, (2) encourage and facilitate teaming arrangements, and (3) assist in establishing guidelines for assessing technology efficacy and life-cycle costs.

Ecological Impact/Transport and Transformation: Searches of available databases have revealed minimal information on the ecological effects of ammonium perchlorate or any of its other salts. Essentially no reliable data exist for its effects on various soil, sediment or aquatic receptors including: aquatic vertebrates, aquatic or sediment invertebrates, bacteria or plants. Limited data available do suggest effects on thyroid-hormone mediated development in the South African clawed frog, *Xenopus laevis* in the range of 50-100 ppm; and 1000 ppm in recent studies has been shown to completely block the metamorphosis of tadpoles. Effects on development and population growth have also been indicated in the freshwater sea lamprey at 100 ppm and the freshwater hydra at 350 ppm. Mortality was observed in cold water trout (6000-7000 ppm) and *Daphnia magna* (670 ppm). Effects on seed germination and growth of agricultural plants were reported at 10 ppm.

Approaches for the evaluation of effects on ecological receptors is complicated by the lack of data on its environmental transport and transformation processes. These include data on the effects of soil chemistry (soil composition, adsorption processes, particle size and water saturation, complexation behavior with humic and fulvic materials, pH, etc.), movement characteristics in various media, adsorption to soils of high and low cation and anion exchange capacity, and the effect of ammonia. Development of predictive environmental transport and transformation models would be useful both to assessing ecological impact as well as directing sampling strategies to determine occurrence monitoring sites.

The ecological and transport and transformation processes of perchlorate are not well-characterized at this time and warrant further research. There is concern by agricultural interests about the possible translocation of perchlorate into irrigated food crops and the public becoming alarmed that the crops may be unsafe. The USAF/Detachment 1, Human Systems Center, Brooks AFB has developed a proposal for a battery of screening level bioassays in laboratory-reared organisms representative of ecological receptors across soil, sediment, and water column receptors to evaluate dose-response relationships. The AWWARF had proposed a project to develop retardation rates and other inputs for use in existing computer models to forecast the movement of perchlorate contamination in a variety of aquifer types. This type of data is requisite for development of accurate forecast models.

the potential
public perception
of ~~contaminants~~
food safety

Additional research on the effect of perchlorate on various ecological receptors across soil, sediment and water columns is warranted. The screening battery proposed by the USAF would give essential preliminary data on various ecological receptors and is recommended. Research on the transport and transformation processes, especially on the effects of modifying factors such as the effects of soil chemistry (soil composition, adsorption processes, particle size and water saturation, complexation behavior with humic and fulvic materials, pH, etc.) movement characteristics in various media, adsorption to soils of high and low cation and anion exchange capacity, and the effect of ammonia is also required; particularly if directed toward development of predictive models. Consideration should be given to the need for research to develop retardation rates and other data inputs for use in existing computer models to forecast the movement of perchlorate contamination in a variety of aquifer types. A question remains as to whether ecological effects and transport/transformation have been adequately characterized. Additional research in these areas may be necessary.

APPENDIX A

Toxicology Studies Funded in FY98

STUDY TYPE	DESCRIPTION	4Q97	1Q98	2Q98	3Q98	4Q98	COST (\$K)	SPONSOR
1. Neurobehavioral Developmental	Tests nervous system of fetal, newborn and young animals	X	X	X			310	USAF
2. 90-Day Study; all organs + thyroid hormone levels	Tests many organs of young adult animals	X	X	X			310	USAF
3. Kinetics (<i>in vitro</i> studies/ perchlorate discharge tests) literature review	Tests for mechanism of toxicity	X	X				In-house literature review	USAF
4. Segment II Developmental + thyroid hormone levels	Tests for birth defects		X	X	X	X	200	PSG ¹
5. ADME (Absorption, Distribution, Metabolism and Elimination) a. Literature Review b. Kinetics Study c. Mechanistic Study (3 phases)	Compares how perchlorate is absorbed, metabolized, and excreted in animals and humans	X	X	X X X	X X	X X	Internal 200 180	USAF/PSG NASA NASA
6. Genotoxicity	Tests for mutations and toxic effects on DNA		X	X			37	PSG
7. Reproductive Toxicology + thyroid hormone levels	Tests for reproductive performance in adults, and for toxicity in young animals		X	X	X	X	399	PSG
8. Immunotoxicity	Tests for immunotoxicity in adults			X	X	X	275	US Army

X = Study in Progress

¹Perchlorate Study Group. A consortium of defense contractors and manufacturers including: Alliant Techsystems, American Pacific/Western Electrochemical Company, Atlantic Research Corporation, Lockheed Martin, Thiokol Propulsion Group, and United Technologies Chemical Systems.

Attachment B

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22. \$6,000,000 for the Mine Waste Technology Evaluation Program and Berkeley pit integrated demonstration activities through the National Waste Technology Testing and Evaluation Center.

23. \$1,500,000 to support external research on *Pfiesteria*. The conferees are concerned about the recent rash of fish killings and human sickness due to a marine biotoxic outbreak labeled *Pfiesteria*, in east coast waterways. In complementing current local and state efforts, the conferees direct a national research program that would evaluate competitive, peer-reviewed proposals to understand the causes, mechanisms, and health and environmental effects of *Pfiesteria*. Additional funding is appropriated in the environmental programs and management account.

The conferees have agreed to the following reductions from the budget request:

1. \$5,078,000 from the Climate Change program.
2. \$6,218,000 from the Global Change program.
3. \$2,000,000 from the Advanced Measurement Initiative.
4. \$8,000,000 from the new Environmental Monitoring for Public Access and Community Tracking program.
5. \$5,000,000 from graduate academic fellowships.
6. \$7,000,000 from advanced funding of a planned fiscal year 1998 lease requirement and savings due to a rate recalculation for the Working Capital Fund.
7. \$21,273,400 as a general reduction.

The conferees are aware that orimulsion, a mixture of bitumen and water, is being considered for generating electricity in the United States. While orimulsion has been used in several countries including Japan, China, Italy and Canada's maritime provinces, it has not been utilized within the United States. Because little is known about the risks associated with the introduction of this new product, the conferees direct EPA to initiate a research activity to provide better scientific data on the qualities and characteristics of this product and the potential environmental impact of its introduction.

In addition to the funds specifically provided for perchlorate research within the Crafton-Redlands Plume, the conferees direct the Agency to work with the Department of Defense, the National Institute of Environmental Health Sciences, and other appropriate federal and state agencies to, (1) assess the state of the science on the health effects of perchlorates on humans and the environment and the extent of perchlorate contamination of our nation's drinking water supplies, and, (2) make recommendations to the House and Senate Committees on Appropriations within six months of enactment of this Act on how this emerging problem might be addressed.

The conferees note the important ongoing research activities at EPA to develop a comprehensive view of the air quality impacts resulting from swine confinement operations. The EPA is directed to coordinate these research activities working in conjunction with those efforts currently underway at the Agricultural Research Service and with other public and private research efforts.

Following consultation with the Environmental Protection Agency, the National Academy of Sciences, and numerous scientific and research and stakeholder groups, the conferees have developed

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Technology Transfer: Accurate information and communication tools are needed to keep utilities and their customers informed regarding the state-of-the-science and important issues regarding perchlorate toxicity, analytical detection methods, occurrence, treatment technologies, and ecological impact and environmental transfer and transformation in summarized and simple formats. Effective tools that reach a broad spectrum (i.e., not just those with access to the Internet) of the public, such as fact sheets, teleconferences, an updated Web page, and news releases should be developed. These same needs were identified by the AWWARF October 1997 workshop and echoed in the first two public teleconferences of the IPSC. The IPSC subcommittees have been charged with developing fact sheets and the EPA OW has developed a website with links to OSWER and ORD. EPA regional offices have been working with state and local authorities on news releases. The IPSC is also planning a May 1998 public meeting for information distribution on the key issues and to hear stakeholder and public concerns in Henderson, Nevada. held.

Development of fact sheets, maintenance of a website, and other communication tools is underway as a cooperative effort between the IPSC and the EPA's OW. OW is undertaking this activity as part of its regular program operations.

RECOMMENDATIONS SUMMARY

The EPA's ORD, in conjunction with the other IPSC members, have assessed the state of the science regarding the effects of perchlorate on human health and the environment, including an evaluation of the extent of perchlorate contamination. Future consideration is recommended for research in the following areas to address the emerging issues associated with perchlorate contamination:

- Occurrence survey
- Health effects / toxicology
- Analytical detection methods
- Treatment technologies
- Ecological impact / transport and transformation

It is also recommended that the IPSC continue to coordinate interagency activities to facilitate and coordinate accurate accounts of related technical issues and to create information transfer links for interagency and intergovernmental activities.

FACSIMILE COVER SHEET

ORMA/RPES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research And Development
Office of Resources Management and Administration (8102R)
1300 Pennsylvania Ave., NW, Washington, D.C. 20004

To: Laura Yoshii, Nora L. McGee, Wayne Perkins, Kevin Meyer
SFD SFD

Organization: Region IX

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Brent

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Dana Bond
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3342 Brent Bond

Date: 06/03/98

Number of Pages (Including This Cover Sheet): 16

Message: _____

RPES FACSIMILE NUMBER (202/565-2908)

RPES PHONE NUMBER (202/564-6685)



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN - 2 1998

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: FY 1998 Appropriations Reporting Requirement on Perchlorate

FROM: Stephen A. Lingle *Stephen A. Lingle*
Acting Deputy Assistant Administrator for Management (8101R)

TO: Dana D. Minerva
Deputy Assistant Administrator
Office of Water (4101)

Michael Shapiro
Acting Principal Deputy Assistant Administrator
Office of Solid Waste and Emergency Response (5101)

Laura Yoshii
Acting Deputy Regional Administrator
Region IX

William W. Rice
Deputy Regional Administrator
Region VII

PURPOSE

The purpose of this memorandum is to request that the Office of Water (OW), the Office of Solid Waste and Emergency Response (OSWER), and Region VII and IX review and comment on the attached draft Report to Congress, "Perchlorate: Assessment of the State of the Science."

BACKGROUND

In the Conference Report (Committee Report 105-115, October 6, 1997, see Attachment B), to accompany the 1998 Appropriation Bill, Congress directed the



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U.S. Environmental Protection Agency to work with the U.S. Department of Defense (DoD), National Institute of Environmental Health and Sciences (NIEHS), and other appropriate federal and state agencies to:

- (1) Assess the state of the science on the health effects of perchlorates on humans and the environment and the extent of perchlorate contamination of our nation's drinking water supplies, and
- (2) Make recommendations to the House and Senate Committees on Appropriations within six months of enactment of the 1998 Appropriation Bill on how this emerging program might be addressed.

The Office of Research and Development's (ORD) National Center for Environmental Assessment (NCEA) developed the attached draft Report to Congress in conjunction with representatives from OW (Mike Osinski), OSWER (Peter Gravatt), and Region IX (Wayne Praskins and Kevin Mayer), as part of an Interagency workgroup, the Interagency Perchlorate Steering Committee. We are also providing a copy of this draft to Region VII, as ORD's lead Region.

ORD requests your review and comment on the report, so that it can be finalized and provided to the Office of Management and Budget for their review. We would appreciate receiving your comments by Wednesday, June 10, 1998, so that we may incorporate them and provide the Agency with a final version when possible. Please provide your comments to Joe Corbett of NCEA at your earliest convenience. If you have any questions, please contact Joe at 202-564-8352.

Attachments

cc: Larry Reiter, ORD
Bill Farland, ORD - {cx}
Debbie Dietrich, ORD
Mike Feldman, OCFO
Nora L. McGee, Region IX
David Swack, OW
Ika Joiner, OSWER
John Helvig, Region VII
Mike Osinski, OW
Peter Gravatt, OSWER
Wayne Praskins, Region IX
Kevin Mayer, Region IX

PERCHLORATE: ASSESSMENT OF THE STATE OF THE SCIENCE EPA OFFICE OF RESEARCH AND DEVELOPMENT MAY, 1998

In the Conference Report (Committee Report 105-115, October 6, 1997) to accompany the 1998 Appropriation Bill, Congress directed the U.S. Environmental Protection Agency to work with the U.S. Department of Defense (DoD), National Institute of Environmental Health and Sciences (NIEHS), and other appropriate federal and state agencies to:

- (1) Assess the state of the science on the health effects of perchlorates on humans and the environment and the extent of perchlorate contamination of our nation's drinking water supplies, and
- (2) Make recommendations to the House and Senate Committees on Appropriations within six months of enactment of the 1998 Appropriation Bill on how this emerging program might be addressed.

WHAT IS PERCHLORATE?

Perchlorate anion (ClO_4^-) originates as a contaminant in ground and surface waters from the solid salts of ammonium, potassium, or sodium perchlorate.

*states
explosives*
Ammonium perchlorate is manufactured for use as an oxidizer component in solid propellant for rockets, missiles, and fireworks. Because of its shelf life, it must be periodically washed out of the country's missile and rocket inventory and replaced with a fresh supply. Thus, large volumes of the compound have been disposed of in California and likely other sites since the 1950's. Ammonium perchlorate is also used in certain munitions, fireworks, the manufacture of matches, and in analytical chemistry.

Potassium perchlorate had, until recently, been used therapeutically to treat hyperthyroidism resulting from an autoimmune condition known as Graves' disease. Potassium perchlorate is still used diagnostically to test thyroid hormone (TSH, T3 and T4) production in some clinical settings. The basis for the effect on thyroid hormone function is the competitive inhibition of iodide anion uptake by perchlorate which results in reduced thyroid hormone production. Thyroid hormone deficiencies can affect normal metabolism, growth and development. The limited database on the toxicology of perchlorate confirms its potential to disrupt thyroid hormone production in mammalian test species, but no robust data exist to evaluate other potential target tissues or effects. There are no data to evaluate the effects of perchlorate in potentially susceptible population such as developing fetuses or its effects on ecological systems.

Perchlorate salts are quite soluble in water. The resultant anion (ClO_4^-) is exceedingly mobile in aqueous systems and can persist for many decades under typical groundwater and surface water conditions, due to kinetic barriers to its reactivity with other available constituents. Recent (April 1997) advances in the analytical detection capability for low concentrations of perchlorate [from 400 parts per billion (ppb) to 4 ppb] have led to the discovery of the chemical at various manufacturing sites as well as in well-water and the drinking water supplies of communities in California, Nevada, and Utah. Perchlorate has been found at 6 Superfund National Priorities List (NPL) sites in California (Aerojet and Mather Air Force Base, San Gabriel Valley, National Aeronautics and Space Administration (NASA)-Jet Propulsion Laboratory (JPL), Edwards Air Force Base and unconfirmed samples at the San Fernando Valley site), at 6 other California non-NPL sites, two sites in Henderson, Nevada area and at one site in Utah. Water suppliers in both northern and southern California, and the Las Vegas Water Authority have found perchlorate in their systems generally at levels less than 18 ppb but ranging as high as 280 ppb, with several in the 100-200 ppb range. Perchlorate has been detected at low levels (5 to 9 ppb) in the Colorado River, which potentially affects the water supply of over 1 million in Nevada, 1 million in Arizona and over 10 million in California as well as Native Americans along the river.

LLNL site 300

Reports More than 150 sites in approx. 43 states
of use or manufacture

SCIENTIFIC UNCERTAINTIES

Perchlorate is of concern because of the existing uncertainties in (1) the toxicological database documenting its health effects at low levels in drinking water, (2) the actual extent of the occurrence of perchlorate in ground and surface waters which is compounded by some uncertainty in the validation of the analytical detection method, (3) the efficacy of different treatment technologies for various water uses such as drinking water or agricultural application, and (4) the extent and nature of ecological impact or transport and transportation phenomena in various environmental media.

Perchlorate does not have a National Primary Drinking Water Regulation (NPDWR) or Health Advisory (HA) established. In accordance with the 1996 amendments to the Safe Drinking Water Act (SDWA), the Environmental Protection Agency (EPA) is required to develop a list of contaminants that are potential candidates for future drinking water research, guidance development, and future regulation, if necessary. Based on response to public comment received on its draft list published on October 6, 1997 (62 FR 52193), perchlorate has been included on the Contaminant Candidate List (CCL). At this time, the CCL notes that additional data on health effects, occurrence, analytical methods and treatment technologies are needed for perchlorate before decisions can be made to (1) regulate with a NPDWR, (2) develop guidance and/or a HA, or (3) do nothing. This list will also serve as a source to identify unregulated contaminants for required monitoring by the States. There are bills pending in the California state legislature (SB 1033) to mandate that the California Department of Health Services (CalDHS) adopt a primary drinking water standard by July, 1999. California has also initiated legislation to appropriate funding to the University of California to conduct a study and

assessment of the occurrence, treatment, and health effects associated with groundwater contamination from perchlorate (AB 2392 February 20, 1998).

The EPA Superfund Technical Support Center issued a provisional reference dose (RfD) in 1992 and a revised provisional RfD in 1995, resulting in a recommended range of 4 - 18 ppb as a guide for ground water cleanup levels at Superfund sites. The CalDHS adopted the provisional action level of 18 ppb, and EPA's Region III has placed this provisional value on its Risk-Based Concentration Tables.

Based on detection of perchlorate in drinking water sources along the Crafton-Redlands plume in the East Valley Water District (EVWD), and concern for the uncertainties and issues listed above, the FY98 appropriations provided a Congressional add-on of \$2M for research on perchlorate, with an emphasis on treatment technologies. In anticipation of this funding, the EVWD, in cooperation with four other water suppliers (Main San Gabriel Basin Watermaster, Metropolitan Water District of Southern California, San Bernardino Valley Municipal Water District, and the Southern Nevada Water Authority) sponsored a research planning workshop which they requested the American Water Works Association Research Foundation (AWWARF) to organize and manage. The AWWARF staff agreed and convened an expert workgroup that included the CalDHS, EPA Region IX, university professors and researchers, Aerojet and the United States Air Force (USAF), consultants and other research experts as well as technical representatives of the sponsoring water utilities. Using a modification of the planning process for other AWWARF research issue groups, the AWWARF conducted the workshop in Ontario, California, on September 30 to October 2, 1997 to develop and prioritize project descriptions. The overall research plan covered 4 years, 1998 through 2001. The Request For Proposal (RFP) for eight of those projects went public during the week of Monday, March 9, 1998. These eight projects include seven that are to be funded by the Congressional FY98 Crafton-Redlands allocation of \$2M. The eighth project is an occurrence survey funded strictly by AWWARF monies. Once the proposals submitted in response to these RFPs are evaluated, contract awards for the seven RFPs to be funded from federal resources are contingent upon release of the designated funding by EPA and the availability of subsequent funding for the duration of the projects.

INTERAGENCY PERCHLORATE STEERING COMMITTEE (IPSC):

An Interagency Perchlorate Steering Committee (IPSC) was formed in January 1998 to bring together government representatives from the EPA, DoD, Agency for Toxic Substances and Disease Registry (ATSDR), National Institute for Environmental Health Sciences (NIEHS), and affected state, tribal, and local governments. Its charter is to facilitate and coordinate accurate accounts of related technical issues (occurrence, health effects, treatability and waste stream handling, analytical detection, ecological impacts, regulatory updates) and to create information transfer links for interagency and intergovernmental activities regarding these areas of concern.

There has been growing interest by various parties to benefit from public briefings and meetings held by the IPSC. An especially interested sector is the impacted water authorities who are keen to learn the most accurate information to communicate to their customers. Monthly teleconferences are held to update participants on events and breaking news regarding controversial or technological issues. A public meeting is currently being planned for mid-May in Henderson, Nevada, to distribute the most current scientific information on the key issues and to hear stakeholder and public concerns. Participation in the IPSC has also been solicited from other governmental members, including the Department of the Interior. *was held May 19-21*

Information on the state-of-the science has been compiled by subcommittees of the IPSC devoted to each of these areas and a summary discussion for each is presented below. This report has been developed by EPA's Office of Research and Development (ORD) in conjunction with the IPSC regarding work required to address the existing areas of concern and uncertainties regarding characterization of the risk of perchlorate contamination in ground and surface waters. This report recommends areas of research for future consideration to address the emerging perchlorate risk characterization issues.

Occurrence Surveys: There has not been a systematic or widespread survey of perchlorate occurrence. Only a small number of water supplies have been monitored at the new level of detection sensitivity, and these have primarily been in the Western States with a few sample results now available in the South. EPA and the State authorities are working together to intercept contaminated groundwater where it has been identified. Reporting of occurrence data is confounded by discrepancies in the type of analytical method used and its detection level of sensitivity. Occurrence information is also likely to be variable due to seasonal water turnover and mixing due to temperature changes, as has been demonstrated in Lake Mead. *(not published)*

An additional National Assessment of Perchlorate Contamination Project was approved by the Board of Trustees of AWWARF for their sponsorship and funding. The RFP for this project went public the week of Monday, March 9, 1998, with proposals due May 4th. The project is proposed as a \$150K AWWARF contract with a required 25% matching in-kind support of the total budget provided by the successful bidder, resulting in an overall project budget of \$200K. It is expected that the contract for this work will be completed in the summer of 1998, with the project to initiate shortly thereafter.

The majority of confirmed sites where perchlorate has been released to the environment in EPA Region IX are associated with operations manufacturing or testing solid rocket fuels for the military or NASA (e.g., Aerojet, NASA-JPL, Lockheed Propellants, Alliant/Hercules, Rocketdyne). *include* The other two known release sites are perchlorate manufacturing facilities in Henderson, Nevada, including the former Pacific Engineering and Production Company (PEPCON) operation. Levels in Utah range from 4 to 200 ppb in ground water wells on the property of rocket motor manufacturer Alliant Techsystems. Wells near the PEPCON explosion site ranged from 51.4 to 630 ppm (51,400 - 630,000 ppb) and those near the manufacturer Kerr-McGee Corporation showed levels as high as 3,700 ppm (3,700,000 ppb). Testing by the

(in 20 mgd!)

Los Angeles Metropolitan Water District found 8 ppb at its intake and in Lake Mead at Hoover Dam. The Southern Nevada Water Authority found levels as high as 14 ppb in its public water supply. The Nevada Division of Environmental Protection reports approximately 1 ppm (1,000 ppb) entering Lake Mead from the Las Vegas Wash. Some samples of Lake Mead surface water were reported as high as 165 ppm (165,000 ppb) near the Las Vegas Wash with most samples in the 10 to 50 ppb range.

EPA Region VI has identified facilities having manufactured or handled perchlorates in some capacity and forwarded this list as well as laboratory analysis information to the Texas Natural Resource Conservation Commission (TNRCC), the Arkansas Department of Pollution Control and Ecology, and the Oklahoma Department of Environmental Quality, as well as to the CERCLA project manager of Longhorn Army Ammunition Plant, with the recommendation that the ground and surface waters near these facilities be tested for perchlorate. Results at one facility (Atlantic Research in Arkansas) were nondetectable perchlorate levels, but the method used had a limit of 1 ppm (1,000 ppb). Levels at the Longhorn Army Ammunition Plant reported storm drain discharge to a creek at 200-400 ppb and the creek discharge into Caddo Lake at 11 ppb; solid perchlorate residual was visible on the soil surface.

Systematic and widespread survey of perchlorate contamination is warranted. EPA anticipates the need for additional field sampling and analysis at sites where perchlorate releases may be contaminating ground or surface water. New information on potential sites across the country is forthcoming from DoD and NASA searches; information requests from perchlorate manufacturers; and from the proposed AWWARF occurrence study. EPA has started to notify State and local governments and tribes when the Agency receives evidence of perchlorate manufacture and use in their jurisdictions. However, due to limited resources and analytical capability, these governmental identities may not be able to investigate further. It is recommended that the EPA regional offices identify facilities having manufactured or handled perchlorate and oversee conducting sampling of ground and surface water near these facilities. Results should be compiled in a report for distribution by the IPSC. A nationwide effort to characterize possible perchlorate contamination in ground and surface water sources of drinking water in areas of high risk is recommended. Such an occurrence characterization would build upon the vulnerability assessment (survey screen) funded in FY98 by AWWARF, and delineate the nature and extent of contamination at critical sites and evaluate the impact on drinking water supplies as well as other potential sources (e.g., sample water systems, surface and ground water sources). The AWWARF perchlorate issue group had proposed a project for such a survey, but the EVWD has indicated that they intend to focus on treatment issues instead.

Health Effects/Toxicology: The toxicology data available to evaluate the potential health effects of perchlorate are extremely limited. The provisional RfD values (1992 and 1995) issued from the EPA Superfund Technical Support Center were based on an acute study in which single doses of potassium perchlorate caused the release of iodide from the thyroids of patients with Graves' Disease. The uncertainty factors applied to these data ranged from 300 to 1000. Standard assumptions for ingestion rate and body weight were then applied to the RfD to calculate the reported range in the ground water cleanup guidance levels of 4 -18 ppb.

The outcome of an external peer review convened in March 1997 of an analogous RfD derivation by an independent organization, Toxicology Excellence for Risk Assessment, was the determination that the health effects and toxicity data were insufficient for a credible quantitative risk analysis. The external peer review panel concluded that the data were not sufficient to rule out effects of perchlorate on other organs, so that it could not be determined unequivocally that the effects on the thyroid were the critical effect. In particular, the reviewers were concerned that developmental toxicity, notably neurological development due to hypothyroidism during pregnancy, could be a critical effect of perchlorate that has not been adequately examined in studies to date. In response to that review, a subsequent external peer review of experts was convened in May 1997 to recommend and prioritize a set of studies to address the key data gaps and reduce uncertainties in various extrapolations. Eight studies were recommended and these were then initiated under various contracts. The recommended studies included: (1) a 90-day subchronic study in order to identify other target tissues and fulfill the minimum database requirement for derivation of an RfD; (2) a neurobehavioral developmental study (evaluates nervous system of fetal, newborn and young animals) to identify a potentially critical effect and subpopulation; (3) a Segment II developmental study (evaluates birth defects) to identify a potentially critical effect and subpopulation; (4) a two-generation reproductive study (evaluates reproductive performance in adults and for toxicity in young animals) to identify a potentially critical effect; (5) studies to understand the pharmacokinetics (how perchlorate is absorbed, distributed, metabolized and excreted) of perchlorate in test animals and humans; (6) cross-species studies of the effects of perchlorate on the iodide uptake mechanism to aid in quantitative extrapolation; (7) genotoxicity assays to evaluate the potential for carcinogenicity by evaluating mutations and toxic effects on DNA; and (8) immunotoxicity studies to identify a potentially critical effect. Funding for the studies was procured and obligated through a variety of sources, principally the USAF and the Perchlorate Study Group (PSG).¹ The protocols for the studies were reviewed by external peer reviewers from the EPA, California EPA, academia, industry, private institutes and Health Canada. EPA's ORD will evaluate the results of these studies as they become available and integrate the new health effects information into a new health assessment in order to revise the provisional RfD derivation by September 1998. EPA's Office of Solid Waste and Emergency Response (OSWER) has the lead on establishing an external peer review of this RfD health assessment in October 1998. This revised and peer reviewed RfD based on a key set of new studies will serve to more accurately characterize the potential health risk associated with perchlorate contamination.

At this time it appears that an adequate set of studies are underway to comprehensively evaluate the potential health effects of perchlorate in laboratory animal studies. The Department of Defense and the PSG have collectively funded the above eight studies costing \$2.2 M (see Appendix A). Additional work may be required to mathematically model the dosimetry (pharmacokinetics) and toxic effects in order to increase the accuracy of a health risk determination, but this will need to be evaluated as the new data become available. An epidemiological study has been proposed to look at infant thyroid hormone data from mothers who were exposed in their drinking water supplies. The analysis would rely on the dose

¹The PSG is a consortium of defense contractors and manufacturers including: Alliant Techsystems, American Pacific/Western Electrochemical Company, Atlantic Research Corporation, Lockheed Martin, Thiokol Propulsion Group, and United Technologies Chemical Systems.

reconstruction data to the level of either a city or census block and will assume either that all women who lived in that area were exposed to that level of perchlorate or impose standard assumptions from other such studies (e.g., 20% of women drink bottled water). The dose reconstruction of what was in the water would have to be constructed on occurrence data once the hydrology in the aquifers and transport and transformation processes can be worked out. The study was proposed by the CalDHS to ATSDR. ATSDR is currently providing the equivalent of one year's salary in staff support for this project in FY 98. However, CalDHS has requested increased support above current levels of staff support.

It appears that an adequate set of studies are underway to comprehensively evaluate the potential health effects of perchlorate in laboratory animal studies. Additional work is warranted to describe quantitatively the dosimetry (pharmacokinetics) and toxic effects with a mathematical model in order to increase the accuracy of a health risk determination. Additionally, research will help to predict quantitatively the effect of perchlorate on iodide uptake (i.e., calculate the inhibition kinetics for the symporter in the thyroid), and subsequent effects on thyroid hormone (TSH, T3 and T4) production, transportation, and metabolism in adult male and female rats and in the developing rat and mother. Development of the dosimetry model would be best accomplished if performed at the Air Force Research Laboratory/Operational Toxicology Branch (AFRL/HEST), due to its previous experience with dosimetry models for developmental toxicity, and in conjunction with intramural support of scientists involved with the health assessment in EPA.

Analytical Detection Methods: Because analytical methods are critical to determining occurrence levels in drinking water supplies and other sources, the urgent need for analytical development work is evident. Historical data based on gravimetry, spectrophotometry, and atomic absorption spectrometry are unreliable because those methods are non-specific for perchlorate. Ion chromatography (IC) is the state-of-the-art technology for analysis. There are several existing IC methods, including the recent analytical method developed by the CalDHS, Dionex, and one developed by the Air Force Research Laboratory/Operational Toxicology Branch (AFRL/HEST). These methods depend upon retention time in a standard to identify any peak with the same or similar retention time as perchlorate in a water sample. It is not known nor has it been demonstrated that other constituents present in water may have similar retention times or interfere with perchlorate at these low detection levels. The robustness of existing ion chromatographic methods for the analysis of perchlorate in water with high total dissolved solids (TDS) has been questioned. The AFRL/HEST has a validation project underway (\$80K in FY98) to conduct a collaborative study across approximately 22 laboratories from all sectors to evaluate the robustness of the existing ion chromatographic methods (including the CalDHS IC method) to detect perchlorate in three types of matrices (low, mid, and high dissolved solids and a negative control) at four different perchlorate concentrations. The objective is to evaluate the variability, reproducibility, accuracy and precision of the IC methods across laboratories and to determine the concentration range of their efficacy in case a different method should prove more suitable for high concentrations. The report of the study is anticipated in July 1998.

There is an overlap with three proposed AWWARF projects, "Survey of the Performance of the CalDHS Analytical Protocol" (\$94K from FY98 EPA/Crafton-Redlands allocation), "Short-term

Perchlorate Laboratory Issues" (\$125K from FY98 EPA/Crafton-Redlands allocation), and the "Inter-Laboratory Study for the Performance Evaluation of the CalDHS Method. While the AFRL/HEST study focuses on TDS as the only water quality parameter of interest, AWWARF was anticipating information on specific interfering ions and a rigorous evaluation of the detection limits for perchlorate. Enhanced coordination of the analytical activities, notably between those of the USAF and AWWARF, has been encouraged by the IPSC and is being pursued.

Waste water methods for samples with high perchlorate concentration and high TDS are needed as well and research should be pursued in parallel. The IC detection method should also be supported by an acceptable alternative method, based on a different principle to verify concentrations of field samples. Two or three analytical methods most likely to achieve success should be pursued for detailed development. These might include, but are not limited to: capillary electrophoresis, liquid chromatography/mass spectrometry, bioassay methods, coulometric detectors, and selective ion-pair agent methods. Development of an alternative method was a project proposed for RFP solicitation by AWWARF.

The FY98 interlaboratory validation study underway by the AFRL/HEST and the FY98 proposed projects by the AWWARF will provide data to evaluate how much additional effort will be required to develop a robust method. Only one aspect of the original analytical method development projects proposed, that of determining the impact on the CalDHS IC method detection limit by potential interferences, remains to be evaluated. Alternative methods to support issues related to natural occurrence studies and health or ecological impact assessments may require development of specific methods for various environmental or biological matrices. Research and development of these alternative methods is recommended. It is also recommended to pursue waste water technology in parallel. Once available, the EPA's Office of Water (OW) should review the results of these analytical methods studies to evaluate their appropriateness for publication as a standardized EPA analytical detection method for perchlorate.

*good
more
analysis?*

Treatment Technologies: Perchlorate anion is very unreactive towards most reducing agents when cold and dilute and has low reactivity as an oxidant due to kinetic barriers. These same properties make developing treatment technologies difficult, especially at low concentration levels. No one technology or process will likely provide an effective solution for every occurrence of perchlorate contamination in water supplies due to a large number of independent variables. These include, but are not limited to, perchlorate contamination levels, aquifer types, hydrogeology, and the scale and attributes (e.g., soil or water type) of the site to be remediated; the presence of co-contaminants; Federal, state and local regulatory constraints; public acceptance; inherent technology or process limitations and side effects; and capital and operating costs. Technology evaluation criteria may also be a function of the intended use of the treated water (e.g., drinking water versus agricultural application). Technologies and processes have been developed by industry and the Air Force Research Laboratory - Materials and Manufacturing Directorate (AFRL/MLQE) to recover perchlorate for reuse and to treat residual wastewater containing high concentrations (500-10,000 ppm) perchlorate from the manufacture and maintenance of rocket motors. It is important to note that, to date, the USAF has spent in excess of \$10 M for research and development for these technologies and processes to address high-concentration contamination. A new challenge exists in treating low-concentration (5 ppb to

and ambient temp.

500 ppm) perchlorate present in ground and surface water supplies. These contaminated water bodies are sources of municipal drinking water, and as such, are constrained by regulations with respect to treatment processes that may be applied.

Treatment technologies for addressing perchlorate-contaminated water may be grouped into three general categories: (1) biological and biochemical reactor treatment systems, (2) conventional chemical reactor treatment systems, and (3) separation and concentration technology. The further development of technology in each of these areas will be necessary and essential to provide technically sound, cost-effective treatment options for managing a wide range of perchlorate concentration and water supply situations. Each technology or process has either technical limitations or has not been demonstrated for treating low-concentration perchlorate-contaminated water and requires further development. Drinking water authorities may desire, or be compelled, to reduce the perchlorate level in affected supplies below a legislated value. As such, the need for treatment technology for very-low concentration levels exists regardless of the findings of the toxicology studies.

reliability?

There is currently no treatment process that has been demonstrated effective for treating low-concentration (10 ppb to 500 ppm) perchlorate available for use on drinking water supplies or for treating contaminated groundwater. The limitations of existing technologies warrant research in technology development and demonstration of perchlorate treatment process systems. Based on the results of the toxicology studies being conducted, the technology development strategy will be adjusted, if necessary, to produce short-term treatment options unconstrained by capital and operating cost factors, followed by longer-term more cost-effective solutions. It will also be important to establish criteria and ratings for treatment technology effectiveness, e.g., the ratings available from the National Sanitation Equipment Foundation.

The following areas of research are recommended for future consideration:

- Biological and biochemical reactor treatment systems
- Conventional chemical reactor treatment systems
- Separation and concentration technology
- Development of home treatment devices

The Air Force Research Laboratory - Materials and Manufacturing Directorate (AFRL/MLQE) has extensive experience and expertise in developing and implementing chemical and biological process technology, and in developing and evaluating high-concentration perchlorate treatment technology. The IPSC believes that technology development activities be accomplished through teaming arrangements involving the following organizations: the AFRL/MLQE, AWWARF, EPA innovative technology, respective drinking water authorities in affected areas, and commercial developers and suppliers of drinking water treatment processes.

The Treatment Technology Subcommittee of the IPSC would be the appropriate entity to ~~should~~ (1) collect and disseminate information regarding treatment technology development activities, (2) encourage and facilitate teaming arrangements, and (3) assist in establishing guidelines for assessing technology efficacy and life-cycle costs.

Ecological Impact/Transport and Transformation: Searches of available databases have revealed minimal information on the ecological effects of ammonium perchlorate or any of its other salts. Essentially no reliable data exist for its effects on various soil, sediment or aquatic receptors including: aquatic vertebrates, aquatic or sediment invertebrates, bacteria or plants. Limited data available do suggest effects on thyroid-hormone mediated development in the South African clawed frog, *Xenopus laevis* in the range of 50-100 ppm; and 1000 ppm in recent studies has been shown to completely block the metamorphosis of tadpoles. Effects on development and population growth have also been indicated in the freshwater sea lamprey at 100 ppm and the freshwater hydra at 350 ppm. Mortality was observed in cold water trout (6000-7000 ppm) and *Daphnia magna* (670 ppm). Effects on seed germination and growth of agricultural plants were reported at 10 ppm.

Approaches for the evaluation of effects on ecological receptors is complicated by the lack of data on its environmental transport and transformation processes. These include data on the effects of soil chemistry (soil composition, adsorption processes, particle size and water saturation, complexation behavior with humic and fulvic materials, pH, etc.), movement characteristics in various media, adsorption to soils of high and low cation and anion exchange capacity, and the effect of ammonia. Development of predictive environmental transport and transformation models would be useful both to assessing ecological impact as well as directing sampling strategies to determine occurrence monitoring sites;

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The ecological and transport and transformation processes of perchlorate are not well-characterized at this time and warrant further research. There is concern by agricultural interests about the possible translocation of perchlorate into irrigated food crops and the public becoming alarmed that the crops may be unsafe. The USAF/Detachment 1, Human Systems Center, Brooks AFB has developed a proposal for a battery of screening level bioassays in laboratory-reared organisms representative of ecological receptors across soil, sediment, and water column receptors to evaluate dose-response relationships. The AWWARF had proposed a project to develop retardation rates and other inputs for use in existing computer models to forecast the movement of perchlorate contamination in a variety of aquifer types. This type of data is requisite for development of accurate forecast models.

Additional research on the effect of perchlorate on various ecological receptors across soil, sediment and water columns is warranted. The screening battery proposed by the USAF would give essential preliminary data on various ecological receptors and is recommended. Research on the transport and transformation processes, especially on the effects of modifying factors such as the effects of soil chemistry (soil composition, adsorption processes, particle size and water saturation, complexation behavior with humic and fulvic materials, pH, etc.) movement characteristics in various media, adsorption to soils of high and low cation and anion exchange capacity, and the effect of ammonia is also required; particularly if directed toward development of predictive models. Consideration should be given to the need for research to develop retardation rates and other data inputs for use in existing computer models to forecast the movement of perchlorate contamination in a variety of aquifer types. A question remains as to whether ecological effects and transport/transformation have been adequately characterized. Additional research in these areas may be necessary.

APPENDIX A

Toxicology Studies Funded in FY98

STUDY TYPE	DESCRIPTION	4Q97	1Q98	2Q98	3Q98	4Q98	~COST (\$K)	SPONSOR
1. Neurobehavioral Developmental	Tests nervous system of fetal, newborn and young animals	X	X	X			310	USAF
2. 90-Day Study; all organs + thyroid hormone levels	Tests many organs of young adult animals	X	X	X			310	USAF
3. Kinetics (<i>in vitro</i> studies/ perchlorate discharge tests) literature review	Tests for mechanism of toxicity	X	X				In-house literature review	USAF
4. Segment II Developmental + thyroid hormone levels	Tests for birth defects		X	X	X	X	200	PSG ¹
5. ADME (Absorption, Distribution, Metabolism and Elimination) a. Literature Review b. Kinetics Study c. Mechanistic Study (3 phases)	Compares how perchlorate is absorbed, metabolized, and excreted in animals and humans	X	X	X X X	X X	X X	Internal 200 180	USAF/PSG NASA NASA
6. Genotoxicity	Tests for mutations and toxic effects on DNA		X	X			37	PSG
7. Reproductive Toxicology + thyroid hormone levels	Tests for reproductive performance in adults, and for toxicity in young animals		X	X	X	X	399	PSG
8. Immunotoxicity	Tests for immunotoxicity in adults			X	X	X	275	US Army

X = Study in Progress

¹Perchlorate Study Group. A consortium of defense contractors and manufacturers including: Alliant Techsystems, American Pacific/Western Electrochemical Company, Atlantic Research Corporation, Lockheed Martin, Thiokol Propulsion Group, and United Technologies Chemical Systems.

Attachment B

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22. \$6,000,000 for the Mine Waste Technology Evaluation Program and Berkeley pit integrated demonstration activities through the National Waste Technology Testing and Evaluation Center.

23. \$1,500,000 to support external research on *Pfiesteria*. The conferees are concerned about the recent rash of fish killings and human sickness due to a marine biotoxin outbreak labeled *Pfiesteria*, in east coast waterways. In complementing current local and state efforts, the conferees direct a national research program that would evaluate competitive, peer-reviewed proposals to understand the causes, mechanisms, and health and environmental effects of *Pfiesteria*. Additional funding is appropriated in the environmental programs and management account.

The conferees have agreed to the following reductions from the budget request:

1. \$5,078,000 from the Climate Change program.
2. \$6,218,000 from the Global Change program.
3. \$2,000,000 from the Advanced Measurement Initiative.
4. \$8,000,000 from the new Environmental Monitoring for Public Access and Community Tracking program.
5. \$5,000,000 from graduate academic fellowships.
6. \$7,000,000 from advanced funding of a planned fiscal year 1998 lease requirement and savings due to a rate recalculation for the Working Capital Fund.
7. \$21,273,400 as a general reduction.

The conferees are aware that orimulsion, a mixture of bitumen and water, is being considered for generating electricity in the United States. While orimulsion has been used in several countries including Japan, China, Italy and Canada's maritime provinces, it has not been utilized within the United States. Because little is known about the risks associated with the introduction of this new product, the conferees direct EPA to initiate a research activity to provide better scientific data on the qualities and characteristics of this product and the potential environmental impact of its introduction.

In addition to the funds specifically provided for perchlorate research within the Crafton-Redlands Plume, the conferees direct the Agency to work with the Department of Defense, the National Institute of Environmental Health Sciences, and other appropriate federal and state agencies to, (1) assess the state of the science on the health effects of perchlorates on humans and the environment and the extent of perchlorate contamination of our nation's drinking water supplies, and, (2) make recommendations to the House and Senate Committees on Appropriations within six months of enactment of this Act on how this emerging problem might be addressed.

The conferees note the important ongoing research activities at EPA to develop a comprehensive view of the air quality impacts resulting from swine confinement operations. The EPA is directed to coordinate these research activities working in conjunction with those efforts currently underway at the Agricultural Research Service and with other public and private research efforts.

Following consultation with the Environmental Protection Agency, the National Academy of Sciences, and numerous scientific and research and stakeholder groups, the conferees have developed

Technology Transfer: Accurate information and communication tools are needed to keep utilities and their customers informed regarding the state-of-the-science and important issues regarding perchlorate toxicity, analytical detection methods, occurrence, treatment technologies, and ecological impact and environmental transfer and transformation in summarized and simple formats. Effective tools that reach a broad spectrum (i.e., not just those with access to the Internet) of the public, such as fact sheets, teleconferences, an updated Web page, and news releases should be developed. These same needs were identified by the AWWARF October 1997 workshop and echoed in the first two public teleconferences of the IPSC. The IPSC subcommittees have been charged with developing fact sheets and the EPA OW has developed a website with links to OSWER and ORD. EPA regional offices have been working with state authorities on news releases. The IPSC is also planning a May 1998 public meeting for information distribution on the key issues and to hear stakeholder and public concerns in Henderson, Nevada.

) held a public meeting in May 1998

Development of fact sheets, maintenance of a website, and other communication tools is underway as a cooperative effort between the IPSC and the EPA's OW. OW is undertaking this activity as part of its regular program operations.

RECOMMENDATIONS SUMMARY

The EPA's ORD, in conjunction with the other IPSC members, have assessed the state of the science regarding the effects of perchlorate on human health and the environment, including an evaluation of the extent of perchlorate contamination. Future consideration is recommended for research in the following areas to address the emerging issues associated with perchlorate contamination:

- Occurrence survey
- Health effects / toxicology
- Analytical detection methods
- Treatment technologies
- Ecological impact / transport and transformation

It is also recommended that the IPSC continue to coordinate interagency activities to facilitate and coordinate accurate accounts of related technical issues and to create information transfer links for interagency and intergovernmental activities.